

THE MOLE AND AVOGADRO'S NUMBER

One mole of a substance contains Avogadro's number (6.02×10^{23}) of molecules.

How many molecules are in the quantities below? Show your work.

1. 2.0 moles
2. 1.5 moles
3. 0.75 mole
4. 15 moles
5. 0.35 mole

How many moles are in the number of molecules below? Show your work.

1. 6.02×10^{23} molecules
2. 1.204×10^{24} molecules
3. 1.5×10^{20} molecules
4. 3.4×10^{26} molecules
5. 7.5×10^{19} molecules

GRAM FORMULA MASS

Determine the gram formula mass (the mass of 1 mole) of each compound below.

1. KMnO_4 _____

2. KCl _____

3. Na_2SO_4 _____

4. $\text{Ca}(\text{NO}_3)_2$ _____

5. $\text{Al}_2(\text{SO}_4)_3$ _____

6. $(\text{NH}_4)_3\text{PO}_4$ _____

7. $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ _____

8. $\text{Mg}_3(\text{PO}_4)_2$ _____

9. $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2\text{H}_2\text{O}$ _____

10. H_2CO_3 _____

11. $\text{Hg}_2\text{Cr}_2\text{O}_7$ _____

12. $\text{Ba}(\text{ClO}_3)_2$ _____

13. $\text{Fe}_2(\text{SO}_3)_3$ _____

14. $\text{NH}_4\text{C}_2\text{H}_3\text{O}_2$ _____

15. $\text{Zn}_3(\text{PO}_4)_2 \cdot 4\text{H}_2\text{O}$ _____

MOLES AND MASS

Determine the number of moles in each of the quantities below. Show your work.

1. 25 g of NaCl
2. 125 g of H ₂ SO ₄
3. 100. g of KMnO ₄
4. 74 g of KCl
5. 35 g of CuSO ₄ · 5H ₂ O

Determine the number of grams in each of the quantities below. Show your work.

1. 2.5 moles of NaCl
2. 0.50 mole of H ₂ SO ₄
3. 1.70 moles of KMnO ₄
4. 0.25 mole of KCl
5. 3.2 moles of CuSO ₄ · 5H ₂ O

THE MOLES AND VOLUME

For gases at STP (273 K and 1 atm pressure), one mole occupies a volume of 22.4 liters. What volume will the following quantities of gases occupy at STP? Show your work.

1. 1.00 mole H ₂
2. 3.20 moles of O ₂
3. 0.750 mole of N ₂
4. 1.75 moles of CO ₂
5. 0.50 mole of NH ₃
6. 5.0 g of H ₂
7. 100. g of O ₂
8. 28.0 g of N ₂
9. 60. g of CO ₂
10. 10. g of NH ₃

MIXED MOLE PROBLEMS

Solve the following problems. Show your work.

1. How many grams are there in 1.5×10^{25} molecules of CO_2 ?

2. What volume would the CO_2 in Problem 1 occupy at STP?

3. A sample of NH_3 gas occupies 75.0 L at STP? How many molecules is this?

4. What is the mass of the sample of NH_3 in Problem 3?

5. How many atoms are there in 1.3×10^{22} molecules of NO_2 ?

6. A 5.0 g sample of O_2 is in a container at STP. What volume is the container?

7. How many molecules of O_2 are in the container in Problem 6? How many atoms of oxygen?

PERCENTAGE COMPOSITION, EMPIRICAL AND MOLECULAR FORMULAS

On the line at the left, write the letter of the term that best matches each description below. Each letter can be used once, more than once, or not at all.

(A) Percentage composition

(B) Empirical formula

(C) Molecular formula

- _____ 1. Shows the simplest whole-number ratio of the atoms of elements in a compound
- _____ 2. Shows the actual number of atoms of each element in a molecular compound
- _____ 3. Is determined by comparing the molar mass of the compound with the molar mass of the empirical formula
- _____ 4. Relates the mass of each element in a compound to the entire mass of the compound
- _____ 5. Can be used to determine the empirical formula
- _____ 6. Must sum to 100 percent for all elements in a compound

Solve each of the following problems as directed. Show all your work.

7. A sample of iron oxide has a mass of 1.596 g. On analysis, it was found to contain 1.116 g of iron and 0.48 g of oxygen. Find the percentage composition of this compound.
8. Find the percentage composition of a compound that contains 17.6 g of iron and 10.3 g of sulfur. The total mass of the compound is 27.9 g.
9. Find the percentage composition of a compound containing 32.0 g of bromine and 4.9 g of magnesium.
10. A compound was analyzed and was found to contain 9.8 g of nitrogen, 0.7 g of hydrogen, and 33.6 g of oxygen. What is the empirical formula of the compound?

DETERMINING EMPIRICAL FORMULAS

What is the empirical formula (lowest whole-number ratio) of the compounds below? Show your work.

1. 75% carbon, 25% hydrogen

2. 52.7% potassium, 47.3% chlorine

3. 22.1% aluminum, 25.4% phosphorus, 52.5% oxygen

4. 13% magnesium, 87% bromine

5. 32.4% sodium, 22.5% sulfur, 45.1% oxygen

6. 25.3% copper, 12.9% sulfur, 25.7% oxygen, 36.1% water

PERCENTAGE COMPOSITION, EMPIRICAL AND MOLECULAR FORMULAS

Solve each of the following problems as directed. Show all your work.

1. Find the percentage composition of a compound that contains 1.94 g of carbon, 0.48 g of hydrogen, and 2.58 g of sulfur in a 5.00-g sample.	7. Find the percentage composition of calcium carbonate, CaCO_3 .
2. A sample of an unknown compound with a mass of 0.847 g has the following composition: 50.51 % fluorine and 49.49 % iron. When this compound is decomposed into its elements, what mass of each element would be recovered?	8. A sample of an unknown compound with a mass of 2.876 g has the following composition: 66.07 % carbon, 6.71 % hydrogen, 4.06 % nitrogen, and 23.16% oxygen. What is the mass of each element in this compound?
3. Find the percentage composition of a compound that contains 2.63 g of carbon, 0.370 g of hydrogen, and 0.580 g of oxygen in a 3.58-g sample of the compound.	9. What is the percentage of hydrogen in acetic acid, $\text{HC}_2\text{H}_3\text{O}_2$?
4. Find the percentage composition of glucose, $\text{C}_6\text{H}_{12}\text{O}_6$.	10. Determine the empirical formula of a compound containing 2.644 g of gold and 0.476 g of chlorine.
5. Find the percentage composition of ammonium phosphate, $(\text{NH}_4)_3\text{PO}_4$.	11. Determine the empirical formula of a compound containing 0.928 g of gallium and 0.412 g of phosphorus.
6. What is the percentage of water in magnesium sulfate heptahydrate, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$?	12. Determine the empirical formula of a compound containing 1.723 g of carbon, 0.289 g of hydrogen, and 0.459 g of oxygen.

<p>13. Find the empirical formula of a compound, given that the compound is found to be 47.9 % zinc and 52.1 % chlorine by mass.</p>	<p>19. Find the molecular formula of a compound that contains 42.56 g of palladium and 0.80 g of hydrogen. the molar mass of the compound is 216.8 g/mol.</p>
<p>14. Find the empirical formula of a compound, given that a 48.5-g sample of the compound contains 1.75 g of carbon and 46.75 g of bromine.</p>	<p>20. Octane, a compound of hydrogen and carbon, has a molar mass of 114.26 g/mol. if one mole of the compound contains 18.17 g of hydrogen, what is the molecular formula?</p>
<p>15. Determine the empirical formula of a compound containing 20.23 % aluminum and 79.77 % chlorine.</p>	<p>21. Find the molecular formula of a compound that contains 30.45 % nitrogen and 69.55 % oxygen. The molar mass of the compound is 92.02 g/mol.</p>
<p>16. Determine the empirical formula of a compound containing 24.74 % potassium, 34.76 % manganese, and 40.50 % oxygen.</p>	<p>22. Find the molecular formula of a compound, given that a 212.1-g sample of the compound contains 42.4 g of hydrogen and 169.7 g of carbon and the molar mass is 30.0 g/mol.</p>
<p>17. Determine the empirical formula of a compound containing 4.288 g of carbon and 5.712 g of oxygen.</p>	<p>23. A compound is known to have a molar mass of 391.5 g/mol. Find its molecular formula, given that analysis of a 310.8-g sample reveals it contains only boron and iodine. The mass of iodine in the sample is 302.2 g.</p>
<p>18. Determine the empirical formula of a compound containing 2.16 g of aluminum, 3.85 g of sulfur, and 7.68 g of oxygen.</p>	<p>24. Find the molecular formula of a compound that contains 56.36 g of oxygen and 43.64 g of phosphorus. The molar mass of the compound is 283.9 g/mol.</p>

MOLARITY AND DILUTIONS PROBLEMS

1. **Molarity**—Find the missing value for each of the following. Show complete work.

<i>Chemical formula</i>	<i>Mass</i>	<i>Volume</i>	<i>Molarity</i>
(A) K_3PO_4	18.00 g	0.0250 L	_____
(B) HBr	135.64 g	_____	4.25 M
(C) CaCO_3	_____	150.0 mL	3.00 M
(D) $\text{Pb}(\text{NO}_3)_2$	16.0 g	50.0 mL	_____
(E) NaCl	_____	125.0 mL	1.50 M
(F) H_2SO_4	143.28 g	_____	6.50 M

2. **Dilution Problems**—Show complete work for each of the following.

- (A) If 20.0 mL of 18-M sulfuric acid (H_2SO_4) has 500.0 mL of water added to it, what is the concentration of the resulting solution?
- (B) How much water must be added to 25.0 mL of 12.0-M hydrochloric acid (HCl) to get a resulting concentration of 0.150 M?
- (C) What initial volume of 15.6-M nitric acid (HNO_3) is required to make 1.0 L of 0.50-M HNO_3 solution?
- (D) What would be the initial concentration of 50.0 mL of a 1.8-M solution of acetic acid ($\text{HC}_2\text{H}_3\text{O}_2$) if 15.0 mL of the concentrated stock solution was required to make it?